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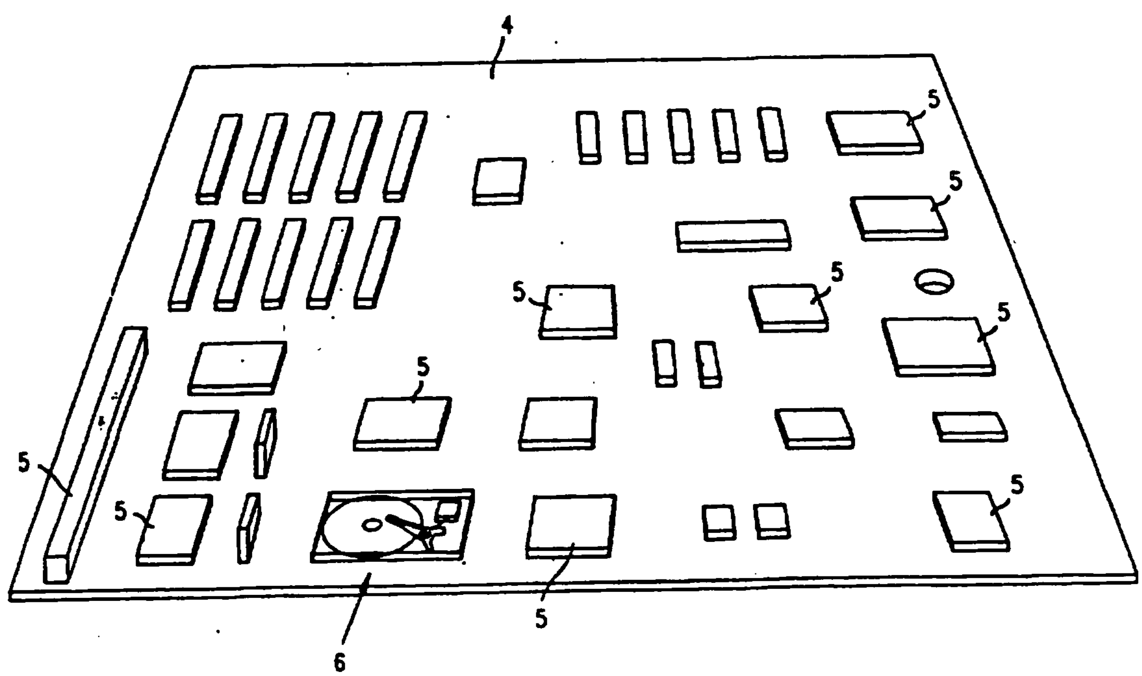


(57) Abstract

An electronic circuit (4) has local storage provided by a miniature disk drive (6).

ELECTRONIC CIRCUIT WITH LOCAL STORAGE

Field of the Invention

The present invention relates generally to an electronic circuit having local storage.

Background of the Invention

Solid state memory is a standard component of computer systems and other electronic devices, providing local storage to the electronic circuit that incorporates it. Some examples of solid state memory components are flash EPROM (erasable, programmable read-only memory), SRAM (static random access memory), and DRAM (dynamic random access memory). One useful function of local storage is to hold small amounts of microcode to be used, for example, for programming programmable circuit components, or for running basic assurance tests (BATS) on other the circuit components. Another useful function of local memory is to store user information, e.g. local storage is used by a pager to store telephone numbers and messages, by a fax machine to store communication protocol parameters, by a printer to store fonts, and so on. For reliability and flexibility, the solid state memory used in such applications is non-volatile and modifiable, e.g. SRAM.

Unfortunately, the cost of solid state memory increases almost linearly with its storage capacity. Moreover, since there are physical limitations to known solid state technologies, an increase in the storage capacity of memory corresponds to an increase in its physical size. These limitations present a foreseeable problem with the growing demand for small, sophisticated, portable, and inexpensive devices with substantial storage requirements.

One area in which the limitations of solid state memory are becoming apparent is card-based electronic circuits. For example, circuits controlling fax machines, modems, cellular phones, printers, cameras, disk drives, and other devices are presently being housed in credit-card sized enclosures of predefined dimensions that plug into a compatible socket of a laptop computer, PC, or other electronic device. Three standard credit-card-sized enclosure formats that have emerged are the PCMCIA formats. A "type III" card measures 10.5 mm in height, 85.6 mm in length and 54 mm in width. The dimensions of a "type II" card are approximately 3.3 mm high X 85.6 mm long X 54 mm wide. A "type I" card is a modest 2.5 mm high X 85.6 mm long X 54 mm wide.

Summary of the Invention

It is an object of the present invention to provide an electronic circuit with an alternative form of local storage which is capable of miniaturisation to roughly the same order of size as conventional solid state memory but is able to be manufactured at relatively low cost with high storage capacity.

This object is achieved by an electronic circuit having local storage provided by a disk drive.

In contrast to solid state memories, magnetic disk drives in general are becoming smaller, and their cost per megabyte is decreasing. It is therefore advantageous to provide a magnetic disk drive small enough to replace solid state memory in electronic devices, such as printers, and in card-based electronic circuits, e.g. PCMCIA formats. Furthermore, magnetic disk drives are ideal for many of the applications discussed above because they provide modifiable, high density, nonvolatile storage.

Until recently, magnetic storage devices have been too large to incorporate directly into an application circuit such as those implemented in PCMCIA type card enclosures. Rather, drives have traditionally been peripheral devices communicating with the application through a peripheral interface.

Recently, however, a number of small disk drives have become available on the market having a size approaching that of a solid state storage device. For example, Hewlett Packard offers a 20-40 MB 1.3" KittyHawk drive. In addition, component type drives are disclosed in U.S. Patent No. 5,264,975, Japanese application nos. 62-270089, 04-291079, and Japanese publication no. 01112586. However, none of these documents considers using a disk drive as local storage within an electronic circuit, wherein the electronic circuit performs a function unrelated to the operation of the disk drive itself, for example, a circuit wherein the disk drive stores microcode for use in the operation of the circuit, or wherein messages received by the circuit are stored in the disk drive, and wherein the electronic circuit uses information stored on the disk drive to perform that function.

In the preferred embodiments, the electronic circuit is provided in a card enclosure, e.g. a PCMCIA type II or III card, and includes in the enclosure a low profile component-sized disk drive having a footprint of less than 50% of the card area, and good resistance to external shock.

In the preferred embodiments, the disk drive comprises a single disk with a diameter of no more than 1.3 inches and a single recording surface, mounted directly to a rotatable flat motor having a diameter of up to 1.3 inches. The disk drive further comprises a single suspension carrying at least one transducer for writing and retrieving data from the disk, and a parking zone at the centre of the recording surface for high shock resistance.

In one embodiment an electronic circuit including a component-sized disk drive is provided wherein the disk drive stores microcode for use in the operation of the circuit. In another embodiment, an electronic circuit including a component-sized disk drive is provided wherein the disk drive stores user information such as telephone numbers and messages.

Brief Description of the Drawings

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a circuit board including a discrete component-sized disk drive for local storage;

Figs. 2(a) and 2(b) show side and top views of a known disk drive including two recording surfaces and two suspensions;

Figs. 3(a) - 3(d) show side and top views of a component-sized disk drive used in the preferred embodiments of the present invention;

Fig. 4 is a perspective view of a typical credit card type electronic circuit enclosure;

Fig. 5 is a top exposed view of a credit card type enclosure housing an electronic circuit that includes a component-sized disk drive for local storage; and

Figs. 6 to 8 are functional block diagrams of various embodiments of electronic circuit apparatus according to the present invention.

Description of the Preferred Embodiments

Fig. 1 illustrates an electronic circuit board 4 generally representative (apart from the disk drive 6) of circuit boards found in a variety of electronic devices. It includes a plurality of interconnected circuit elements 5 such as solid state components, resistors, capacitors, oscillators, and so forth. The solid state components comprise, for

example, a microprocessor, memory, an arithmetic logic unit, a programmable logic unit, etc. The interconnected elements are referred to collectively as the electronic circuit. The electronic circuit also includes a discrete, component-sized disk drive 6 for providing local storage to one or more of the circuit elements 5.

A circuit board such as that represented in Fig. 1 may reside, for example, in a personal computer, a laptop, or other computing device. It may also reside in devices peripheral to a computing device, e.g. controller cards for larger disk drives, printers, modems, fax-modems, and servers. A circuit board is often present in electronic devices such as video cameras, fax machines, cellular phones, electronic pagers, photocopiers, and remote control devices. All of these are likely to have electronic circuits with some local storage requirements.

Figs. 2(a) and 2(b) are side and top views of a known type of disk drive comprising a disk or platter 11 connected to a hub 15, a motor (not shown), an actuator assembly 12, arm electronics 17, and a housing 16. The disk 11 includes a pair of recording surfaces 8,9. The actuator assembly 12 generally comprises a voice coil motor (VCM), an actuator arm 6, and a pair of suspensions 13 connected to the arm 6 and supporting a pair of air bearing sliders 14 over respective recording surfaces 8,9 of the disk 11. One or more transducers or read/write heads are located on each slider 14, and are held in close proximity to the disk surface by the combination of a downward force (relative to the disk surface) from the suspension 13 and an upward force caused by air flow generated from the rotation of the disk 11. If the downward force exceeds the upward force, the slider will come into contact with the disk surface.

The VCM comprises an inductive coil 19 disposed between an upper magnet (not shown) and a lower magnetic plate 7. The arm electronics 17 transmits electrical positioning current to the coil 19. The current signal induces a magnetic flux around the coil for repulsing and attracting the magnet and magnetic plate 7. The repulsing and attracting forces provide movement of the actuator arm in a plane substantially parallel to those of the disk recording surfaces, causing the suspensions 13 to move along an arcuate path over respective surfaces 8,9.

Data is generally recorded on concentric tracks of the recording surfaces 8,9. The disk region or track having the largest diameter is referred to as the outer diameter (OD) of the disk, and the region or track nearest to the hub and having the smallest diameter is referred to as the inner diameter (ID). Data to be stored on the disk 11 is first "encoded" by a read/write channel (not shown) ordinarily residing external to the disk drive housing 16. The data is encoded into a form suitable for the

storage medium, then transmitted via the arm electronics 17 to the transducer for writing to the disk. For example, in a magnetic disk drive, digital data is encoded into a series of pulses. As is known in the art, the pulses are transmitted in the form of a current to the transducer, and cause a fluctuating magnetic field at the transducer pole tip that affects the magnetization of discrete regions on the disk surface. When a transducer senses or "reads" information from the disk, the data is transmitted in encoded form via the arm electronics 17 to the channel for "decoding". The arm electronics usually include means for amplifying and synchronizing the read signal.

The hub 15 is fixedly attached to the disk 11 and encases a motor (not shown) for providing a rotational force. The rotational force is translated to the hub 15 and from the hub 15 to the disk 11. The hub encloses a motor shaft and generally protrudes from the upper surface of the disk as shown in Fig. 2A, preventing the suspension/ head assembly from access to the region at the centre of the disk. To protect a rotary disk drive from external forces during operation or movement, means may be implemented to park the head when the disk is not operating and/or during periods of inactivity (i.e. times when data is not being written to or retrieved from the disk).

Figs. 3(a)-3(d) show the preferred embodiment of the component-sized disk drive used in the electronic circuit apparatus of the present embodiment. The drive comprises a disk 11, a motor 44, an actuator assembly 12, arm electronics 17, and a housing 16. The disk 11 is preferably magnetic and includes one recording surface 42 with a substantially planar region 45 at its centre. It is preferably mounted directly to a flat motor 44 along its nonrecording surface by some appropriate means, e.g. mechanically, or by applying a bonding agent along interface 43. Use of a single recording surface and direct platter mounting allows a wider, thinner motor assembly to be used than would be feasible for a disk having two recording surfaces. The diameter of the motor 44 may be as large or larger than the diameter of the disk 11 itself. The advantages of this type of motor 44 will be described in further detail below.

The actuator assembly comprises a voice coil motor, an actuator arm 6, a single suspension 13 and a transducer-bearing slider 14. Preferably, the slider carries a magnetoresistive (MR) head for greater data capacity. Magnetoresistive heads are known in the disk drive industry and are preferred because their high sensitivity enables greater areal density (i.e. bits per inch) than conventional inductive heads. Using a state of the art magnetoresistive head in the preferred embodiment provides useful data storage capacity for applications requiring moderate data storage. However, it will be understood that other types of transducers may also be

implemented. Moreover, the invention may easily be adapted for a plurality of heads per slider and a plurality of sliders on suspension 13.

Direct mounting of disk 11 to motor 44 creates an unobstructed region 45 at the disk's centre 41 accessible to the actuator assembly 12. The diameter of recording tracks in this region would be too small for practical use, so the region is used for centre parking. Figs. 3(a) and 3(b) show head 14 and suspension 13 positioned over the data recording surface of disk 11. During times of inactivity, the head is "parked" in the central region 45 as shown in Figs. 3(c) and 3(d) so that head 14 is substantially aligned with a central access 41 perpendicular to the disk surface. As the slider 14 nears the inner diameter of the disk 11, the upward force of the air flow is reduced and the slider begins to drag along region 45. It is then "parked" at the disk centre 41 as shown. Parking structures, e.g. ramps, may be added to the centre parking region to facilitate parking. Spacer structures may also be provided between this region and the upper drive housing for added structural support.

The actuator assembly 12 moves the slider back onto the disk surface when necessary by applying a force to overcome the stiction between slider 14 and surface 8. "Stiction" is a term of art for the attractive and frictional forces between slider 14 and surface 8. It is greatest at the outer diameter of the disk and decreases in the direction of the disk centre, being essentially reduced to zero at dead centre. Since the slider is parked at disk centre 41, stiction is virtually nonexistent, and very little force is required to overcome it.

The slider 14 is preferably also centre parked during periods when the drive is not operational. When the drive is powered on, the disk 11 spins without any significant stiction impedance. Reduced stiction translates to a reduction in starting torque required from the motor 44. Reduced starting torque in turn leads to a reduction in the electric power requirements of the drive.

As mentioned previously, the preferred embodiment of the component disk drive allows a flatter, wider motor 44 to be used than conventional disk drives requiring hubs. The motor may take a variety of forms. For example, it may be fixed to the disk drive housing or integrated therein. It may have the shape of a disk, or be annular in shape. It may include a hub, and the disk may be mounted directly to the hub, or alternatively, the hub may penetrate the disk and lie substantially flush with the recording surface to preserve actuator access for centre parking. An annular motor may surround a stationary hub structure that lies flush with the recording surface to provide a stationary parking zone at disk centre.

Those skilled in the art of motor design generally understand that an increase in the diameter of the motor windings increases its moment arm to generate more torque with less force. The motor thus requires less electric current to perform the same operation as a centre hub motor. Since the electrical power (P) is proportional to the square of the current, a reduction in the current requirement will result in a large reduction in the electric power requirement as shown below.

(1) $P = I \times I \times R$, and

(2) $I = k/D$.

Therefore,

(3) $P = (k \times k \times R)/ (D \times D)$,

where P is the electric power of the motor, I is the electric current used by the motor, D is the motor diameter, R is the electric resistance of the motor, and k is the inversely proportional constant of the motor current to diameter. Applying the above equations, an increase of motor diameter by, for example, a factor of 3 will result in a motor that can achieve the same torque with 1/9th of the power. The motor torque is transmitted directly to the bottom surface of the disk through, for example, an adhesive or a coupling device. Examples of motors that may be used to implement the preferred embodiment include those implemented in the commercially available IBM Travelstar, and the Maxtor MobileMax Lite.

Fig. 4 is representative of a card enclosure for an electronic circuit, adapted to be plugged into a compatible computer slot at connector 60. It may, for example, be a PCMCIA card type I, II or III having a predefined length 64, width 63, and height 62. The card thickness 62 is generally the most critical dimension of a card enclosure.

Fig. 5 illustrates generally a preferred embodiment of the electronic circuit apparatus of the present invention. The circuit implements a discrete, component sized disk drive 74 for local storage and resides in a card enclosure such as a PCMCIA type II or type III format, although it will be understood that the circuit apparatus of the present invention may also be enclosed in other card formats, or may form part of the electronic circuit of an electronic device (e.g. a camera) and reside within the device enclosure rather than within a card enclosure. The disk drive assembly 74 preferably measures no more than 2 inches in length 72 X 1.6 inches in width 73 X 5 mm in height.

For example, a 1.3" magnetic disk is mounted to a small, flat motor such as that used in Maxtor's MobileMax Lite. (At present there are no flat motors under 5 mm commercially available for implementation in a type II design. However, availability is anticipated in the near future and prototypes are currently being tested.) The actuator assembly is a conventional dual-suspension design such as that used in the Hewlett Packard KITTYHAWK 1.3" drive, modified to have a single suspension with a magneto-resistive head. Modifications required for operability include removal of the lower suspension and any actuator arm height adjustments necessitated by the height of the direct-mounted disk. It may also be desirable to make additional modifications, e.g. reducing the height of the actuator assembly. The manner of making such modifications will be readily apparent to a person of ordinary skill in the operation of disk drive assemblies in view of this specification and the state of the art.

The disk drive assembly 74 preferably occupies less than 50% of the available card area and has an orientation such as that shown. Alternatively, the drive is oriented such that its length 72 is parallel to the length 64 of the card. The remaining card area is populated by a plurality of electronic components 71 comprising an application subcircuit.

The control functions required to control operation of the drive preferably reside on one or more of the integrated circuit (IC) components 71 within the card enclosure. As those skilled in the art will appreciate, the control electronics include functions such as servo control, an interface, data, address and command buffers, drive motor controls, and a read/write channel. Since the component disk drive is small, the control electronics will be in close proximity to the drive itself. It may therefore also be desirable to include the arm electronics 17 within the control electronics rather than within the disk drive enclosure. The circuit components embodying the control electronics may be dedicated to storage control, or may additionally include non-storage functions. For circuits housed in non-PCMCIA card formats, it may be desirable to locate the storage control components external to the card, e.g. within the electronic device into which the card is plugged.

Referring back to Fig. 5, subcircuit components 71 are mounted to an electronic circuit board 76 occupying the portion of the card unoccupied by the device assembly 74. Conductive means 75, e.g. a flex cable or other connector, couples the drive assembly to the circuit components 71. The conductive means 75 include, for example, control lines, a data bus, and an address bus. If the components controlling the operation of the drive are external to the card enclosure, the appropriate control lines

are routed to connector 60 to provide external access to the assembly 74, as shown.

The drive assembly 74 is preferably enclosed in a separate housing (not shown) within the card enclosure isolating it from the other components for protection against contaminants. Alternatively, the card may be subdivided into two or more isolated sections, or card production may be carefully controlled to minimize the presence of contaminants in the entire card.

Numerous types of electronic devices currently include electronic circuits that use solid state memory for local storage requirements. All of these are viable candidates for implementing a component disk drive in lieu of memory according to the electronic circuit apparatus of the present invention, including, for example, fax machines, cellular phones, printers, cameras, appliances, and portable computing devices.

Fig. 6 is a functional diagram of an electronic circuit apparatus according to the present invention wherein the component disk drive 74 is used for storing microcode. The circuit includes a programmable logic unit (PLU) 127 for performing one or more desired functions which are defined by one or more microcode sets. The PLU may, for example, be programmable array logic (PAL), a programmable logic device (PLD), or a microprocessor with programmable functions. Each microcode set corresponds to a unique PLU function. The PLU 127 typically is linked to one or more non storage related circuit components 128 and may function, for example, as a disk interface between the components 128 and the disk drive 74, as a microprocessor, or as an arithmetic device. The microcode sets are stored locally, i.e. in the component disk drive 74, and then programmed into the unit 127 via a logic programmer 125. Since information on a disk drive is easily updated, additions, deletions, and other modifications may readily be made to the microcode sets.

The component drive 74 is linked to drive control electronics 123. In the interest of conserving space, the drive control electronics are merged with logic programmer 125 into a controller device 122 such as a solid state component, die, multi-chip module, or electronic assembly. The controller 122 optionally includes other functions 124 unrelated to drive control and PLU programming that may require further links to one or more additional circuit components 126.

Fig. 7 shows another specific embodiment of the present invention, wherein the component disk drive 74 stores basic assurance test (BAT) code and tables. As described earlier, BAT code typically resides in EPROM or flash memory, and runs diagnostic tests against components of the circuit

to verify their operability. Verification testing is a desirable feature for card-based applications and electronic devices in general to assure their reliability.

Referring to Fig. 7, a component disk drive 74 and its associated drive electronics 123 are linked to a microprocessor 91 which initiates execution of the BATs. The microprocessor is linked to high speed static ram (SRAM) 92, which, in turn, is linked to test circuitry 95. The test circuitry is part of a circuit loop including the circuit components 104-106 to be tested.

When the processor 91 is in test mode, it receives test microcode from component drive 74, including a table of test patterns that are loaded into SRAM 92. The table includes a plurality of binary input test patterns 93 and their corresponding results 94 expected from a properly working circuit. The next test pattern to be executed and its corresponding expected result are provided to the test circuit, e.g. by loading them into input buffers 96, 99. The test pattern is then forwarded to the components under test, e.g. via an output buffer 98, unless an error signal has been detected by control means 97. Buffers 96 and 98 may actually comprise a series of n latches, where n is the number of bits in the test pattern, and the control means 97 may comprise an inverted error signal coupled to the clock inputs of these latches.

Assuming no error, the next sequential test pattern is loaded into input buffer 96 and the current test pattern is passed through the circuit components 104-106. Each component under test receives the pattern and performs its particular function upon it. The final result is then returned to the test circuitry 95, e.g. into input buffer 102. Comparing means 101 such as a comparator then compare the result in buffer 102 with the expected result in buffer 99. If a mismatch occurs, an error signal is generated and propagated to control means 97 to halt execution of the next pattern in the test sequence. It is also provided to error handling functions (not shown), such as retry circuitry, error indicator means or shutdown means. If a mismatch has not occurred, the next test pattern is passed to the circuit components and the preceding steps are repeated until an error is detected or the test sequence is completed. The functions of test circuit 95 may alternatively be performed by a computer program stored in the component drive 74 and executed by the processor 91.

Another use for a component disk drive is for storing user information. A component drive may be used, for instance, to store telephone numbers, messages, and similar information in any type of portable wireless messaging device.

State-of-the art portable message devices that rely on solid state memories are limited in the amount of information they can store, making them impractical for receiving large documents, electronic mail, pictures and video images. This limitation is overcome by replacing the memory with a component disk drive.

Fig. 8 shows a functional diagram of an electronic circuit apparatus 131 according to an embodiment of the present invention that operates as an electronic pager, wherein a component disk drive 74 provides resident storage for telephone numbers, messages, and other user information. The device is packaged as a peripheral device, e.g. in a PCMCIA card format, or in an independent device packaged conveniently for handheld manipulation.

The pager apparatus 131 of Fig. 8 includes an electronic circuit typical of a conventional digital pager. A processor 132 controls the operation of the device. The processor 132 is coupled to a frequency monitoring wireless receiver circuit 141 comprising, for example, an antenna 134 and receiver electronics 133. The circuit also includes some type of readout display 138, e.g. an LCD display. If the pager is packaged as a peripheral device, it further comprises means for communicating with a computing device 139, e.g. PCMCIA interface electronics 136 disposed between the processor 132 and the card connector 137.

In operation, the wireless receiver circuit 141 "listens" on a predetermined frequency for a particular code or signal indicating a message is to be transmitted. In listening mode, the component drive 74 is powered down to conserve energy. Upon detecting the proper code, the receiver electronics 133 signals the processor 132 to power up to the component drive 74. The receiver circuit 141 then receives the message in the form of electromagnetic radiation and converts it to digital electric impulses. These, in turn, are transmitted via the processor 132 to the drive electronics 123 and are stored magnetically on the component drive 74. Once the message is received, the display 138 may display the message or post a notice that a message has been received. Then the drive 74 is again powered down, and the circuit returns to a listening mode.

The pager circuit just described is capable of storing lengthy messages. For independent devices, this would necessitates a reasonably large display means. Alternatively, if the device is implemented as a peripheral, messages can be stored away for later access. The user then displays his messages by plugging the device 131 into a computing device 139, e.g. a laptop computer. The computing device accesses the information on the component drive 74 and displays it on a monitor (not shown).

Since the component drive of the pager implementation of Fig. 8 is powered down much of the time, energy consumption of the unit is relatively low. Consequently, the circuit may be powered by an independent power source, such as a battery pack 135. Alternatively, or in addition, it may rely on a power supply (not shown) in computing device 139.

A peripheral pager can be carried much like a digital pager, using it's batteries to power up the component drive when necessary. Since messages are immediately received and available for access, the user is no longer required to place a phone call to obtain the information. Standard encryption techniques are preferably employed for security to assure the security of the information. In addition, the device preferably further comprises a wireless transmitter (not shown) for return communication. Information to be transmitted is entered into the computing device 139 and downloaded into the component drive. It may then be transmitted immediately, or at a later time.

CLAIMS

1. An electronic circuit (4) having local storage provided by a disk drive (6).

2. An electronic circuit as claimed in claim 1, wherein the electronic circuit including the disk drive is mounted in or on a self-supporting unit having one half of an electrical plug and socket connector for connection of the unit to other electronic apparatus.

3. An electronic circuit as claimed in claim 2, wherein the electronic circuit resides in a card enclosure adapted for plugging into a computer slot.

4. An electronic circuit as claimed in claim 3, wherein the card is a PCMCIA type II card or type III card.

5. An electronic circuit as claimed in claim 3 or 4, wherein the disk drive occupies not more than 50% of the card enclosure.

6. An electronic circuit as claimed in any preceding claim, wherein the disk drive stores a basic assurance test program for testing the electronic circuit.

7. An electronic circuit as claimed in any one of claims 1 to 5, wherein the electronic circuit comprises a programmable logic unit (PLU) and a logic programmer for programming the PLU. and wherein the disk drive stores a microcode set for programming the PLU.

8. An electronic circuit as claimed in claim 7, wherein the disk drive stores a plurality of microcode sets for programming the PLU, each corresponding to a unique PLU function.

9. An electronic circuit as claimed in any one of claims 1 to 5, wherein the electronic circuit comprises means for receiving electromagnetically transmitted messages and means for storing the received messages on the disk drive.

10. An electronic circuit as claimed in any one of claims 1 to 5, wherein the disk drive stores a plurality of messages, and wherein the electronic circuit comprises means for electromagnetically transmitting the messages.

11. An electronic circuit as claimed in any preceding claim, wherein the disk drive comprises a disk having a single recording surface, means for

rotating the disk, means for writing information to the recording surface, and means for selectively retrieving information from the recording surface.

12. An electronic circuit as claimed in claim 11, wherein the disk drive further comprises a substantially planar region at the centre of the recording surface, a transducer for writing to and retrieving information from the recording surface, and means for parking the transducer on the substantially planar region.

13. An electronic circuit as claimed in claim 11 or 12, wherein the diameter of the disk is not greater than 1.3 inches.

14. An electronic circuit as claimed in claim 11, 12 or 13, wherein the disk is a magnetic disk.

15. An electronic circuit as claimed in any one of claims 11 to 14, wherein the means for rotating the disk comprises a round, flat motor, and wherein the disk is mounted on the motor.

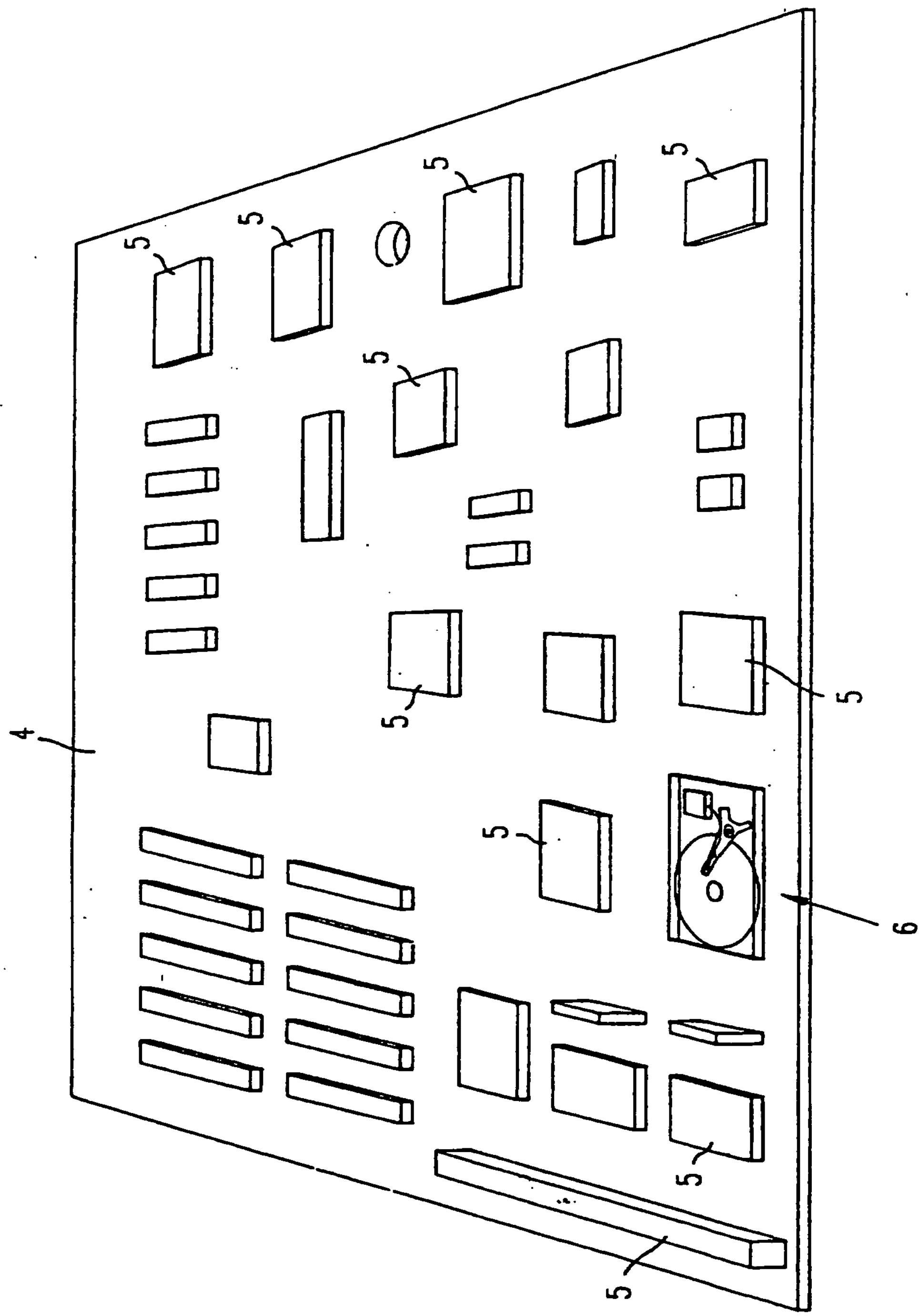


FIG. 1

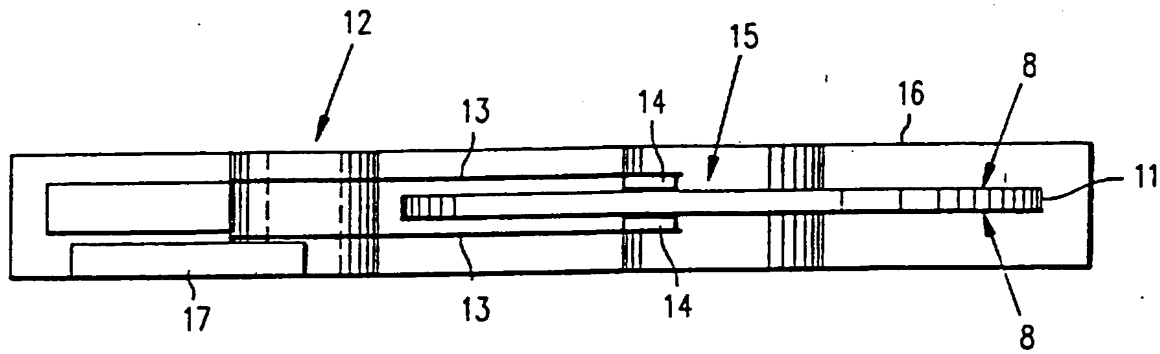


FIG. 2a

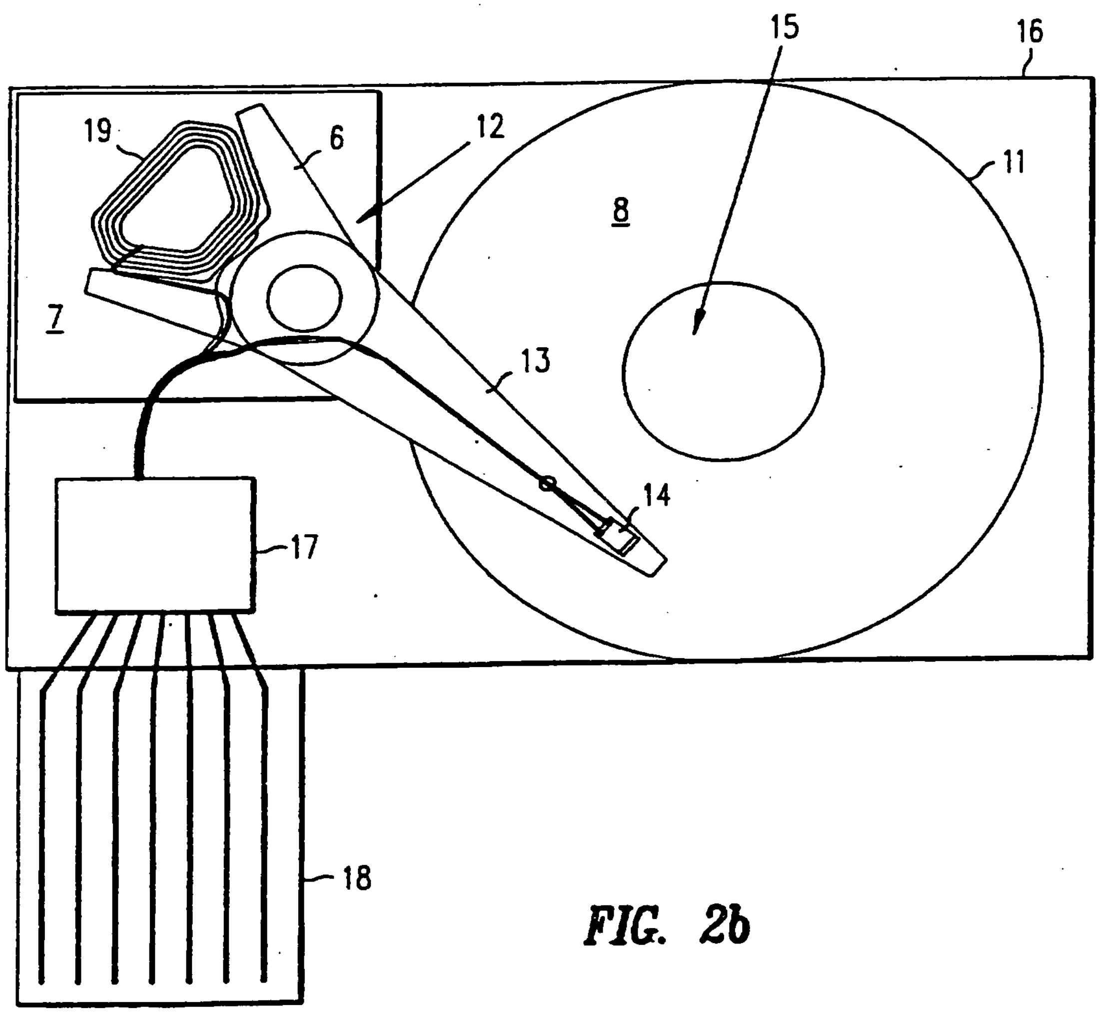


FIG. 2b

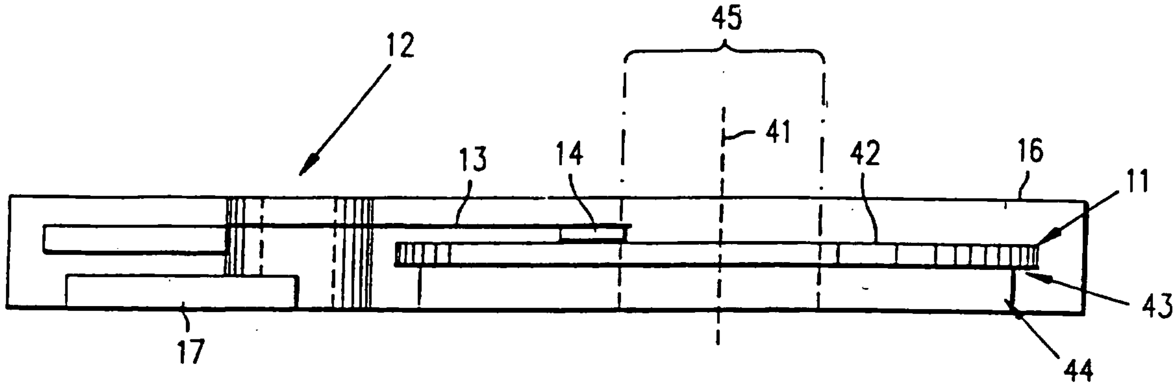


FIG. 3a

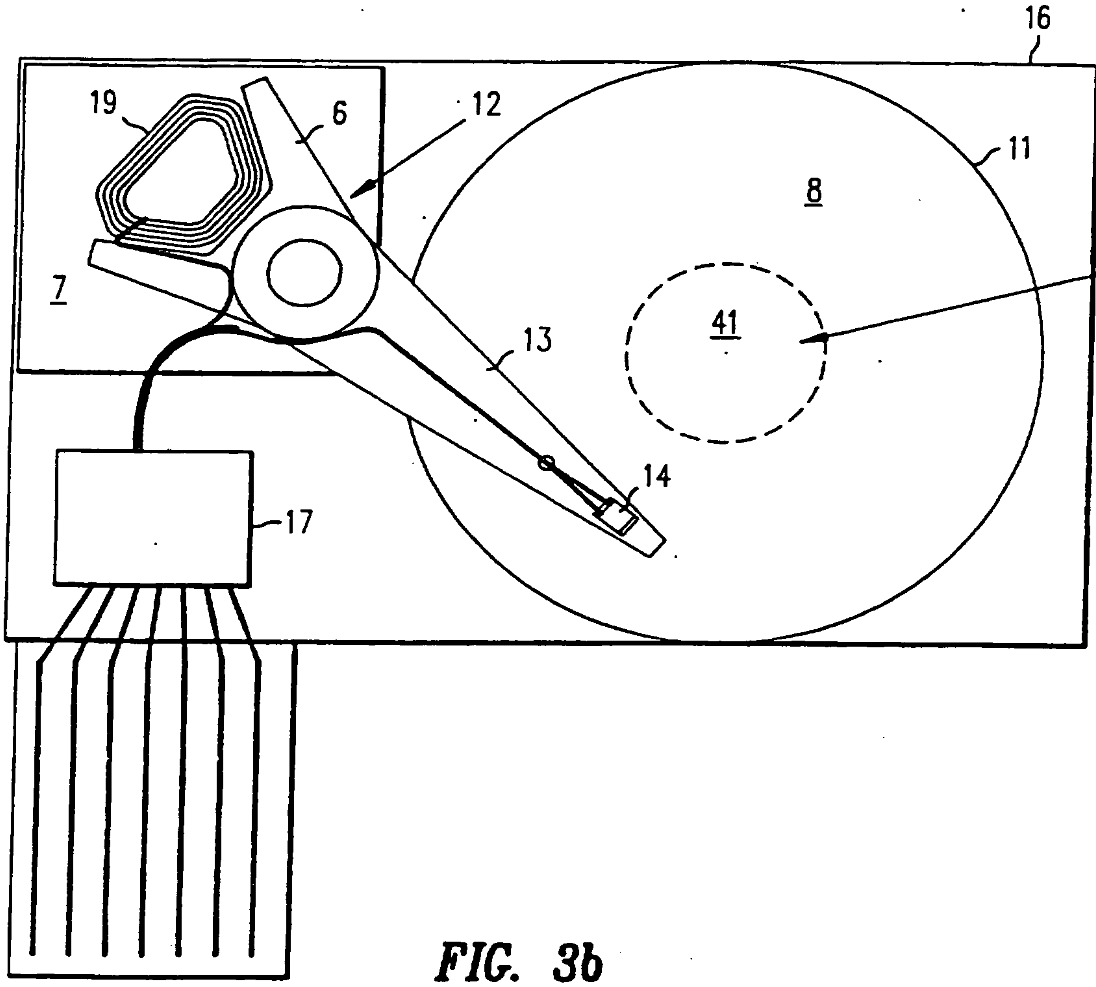


FIG. 3b

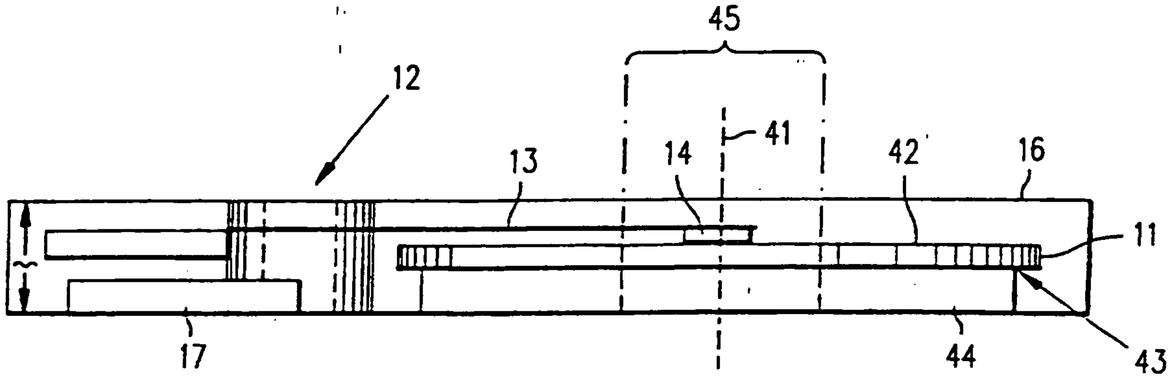


FIG. 3c

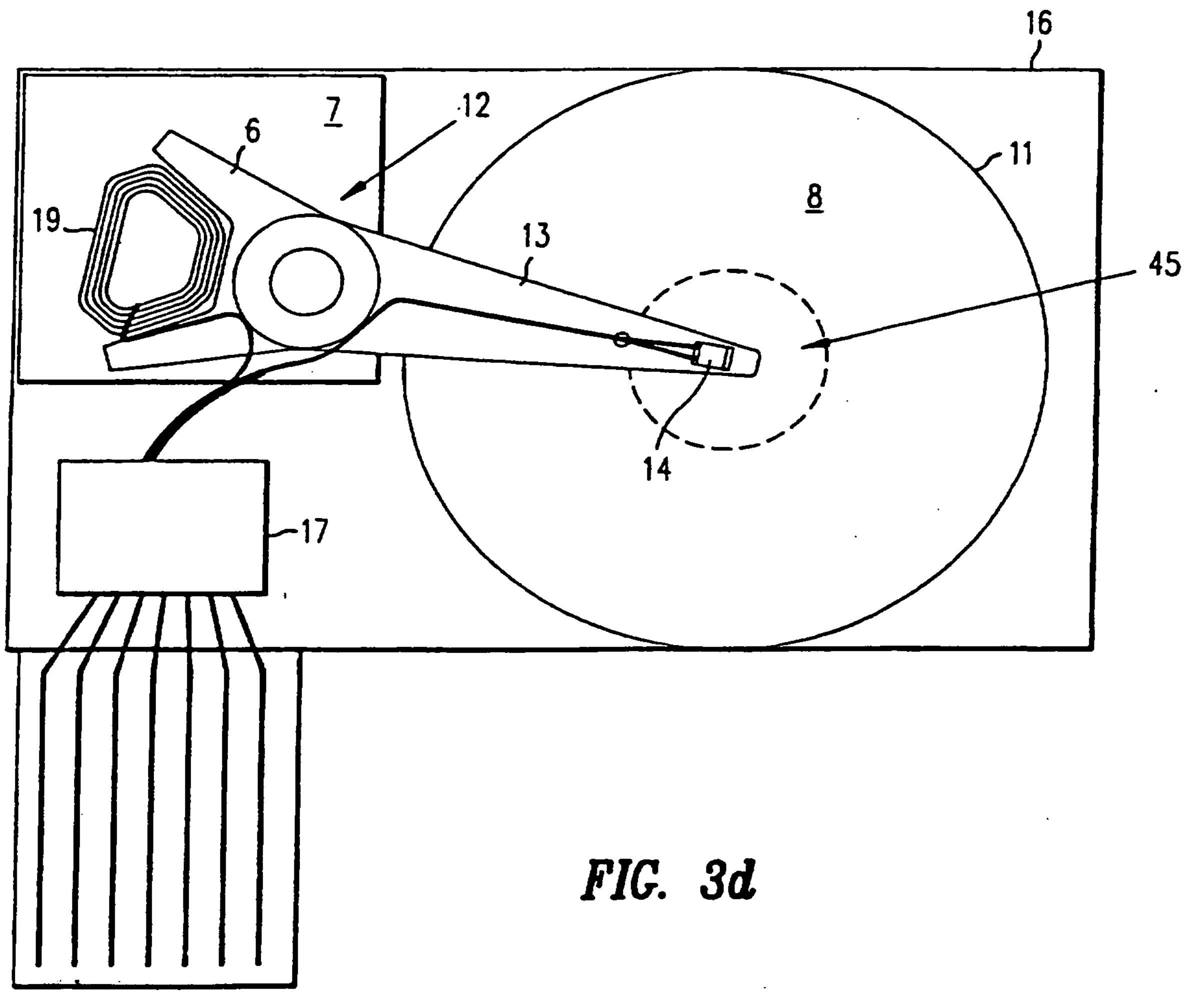


FIG. 3d

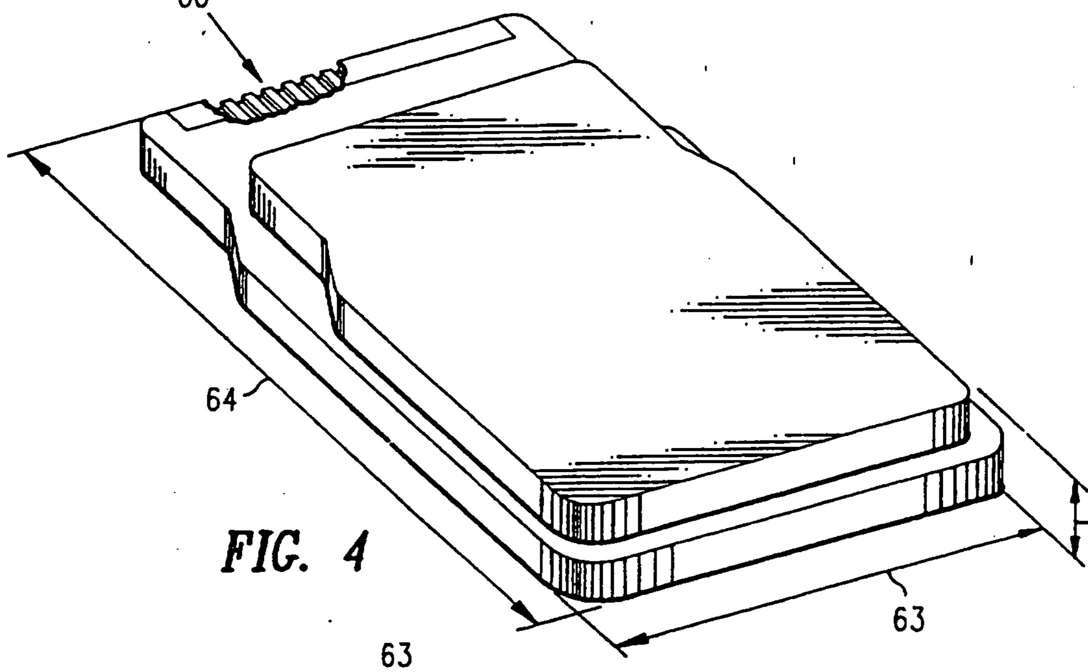


FIG. 4

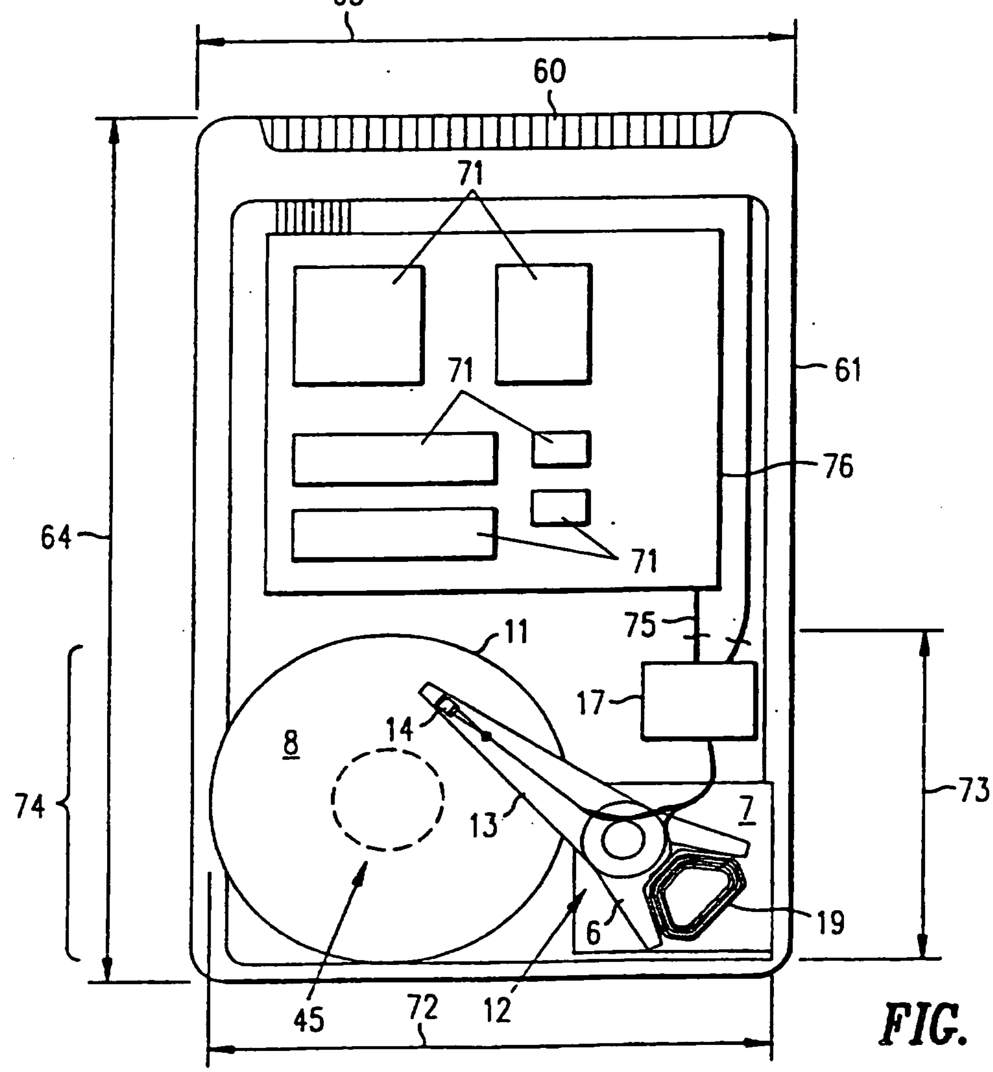


FIG. 5

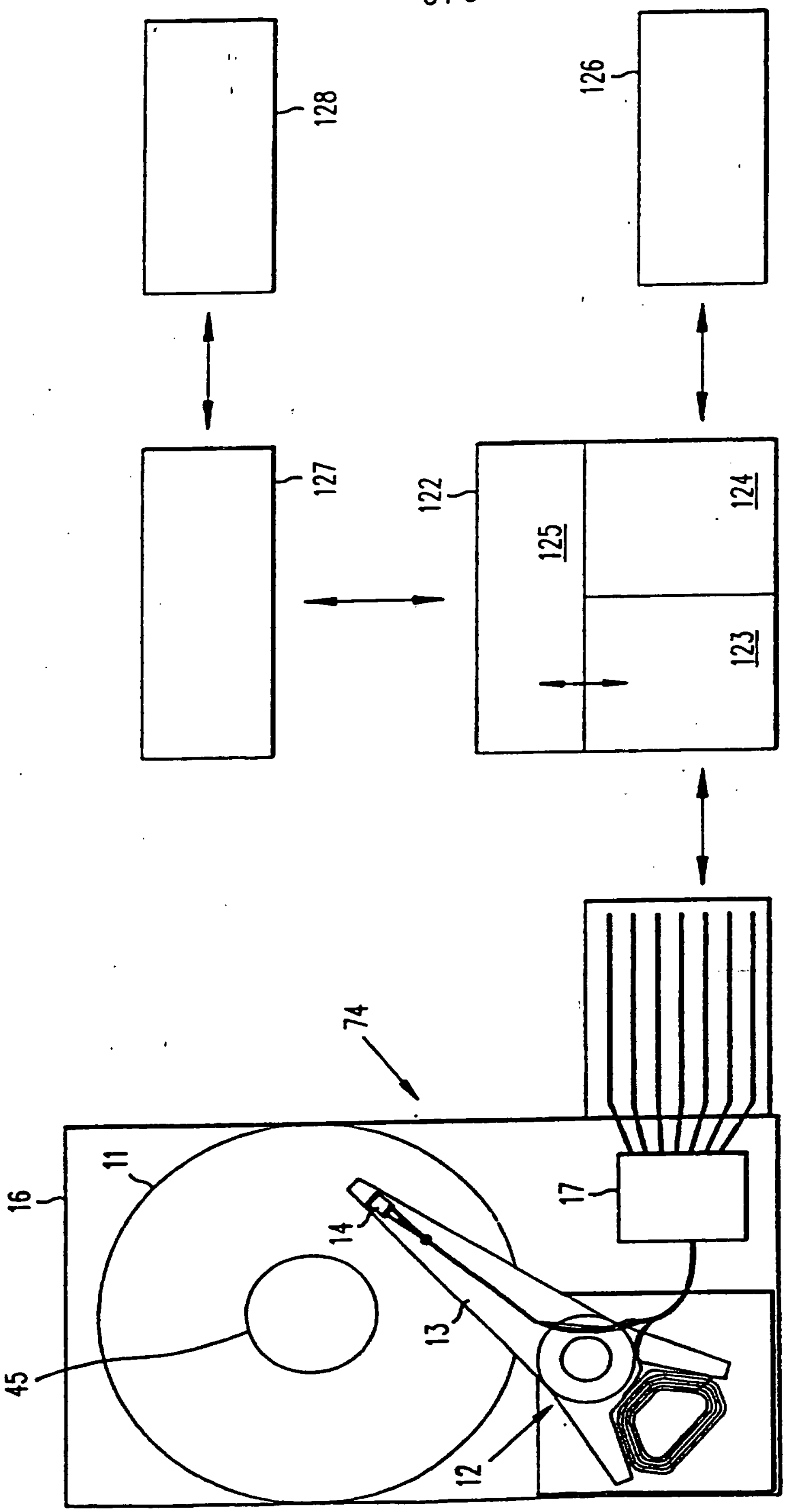
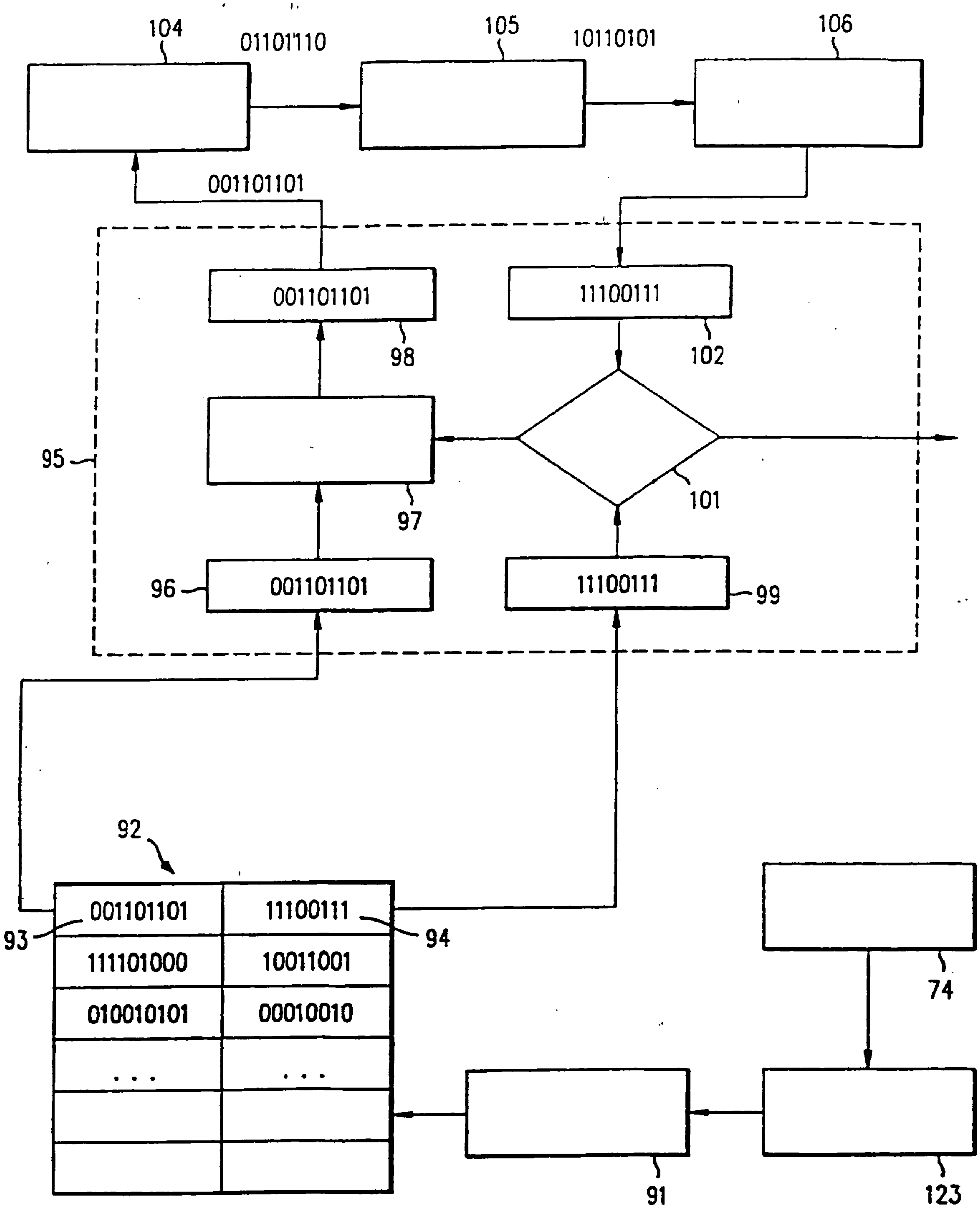


FIG. 6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10110101
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98
102
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96
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99
92
93
001101101
11100111
94
111101000
10011001
010010101
00010010
. . .
. . .
74
91
123

FIG. 7

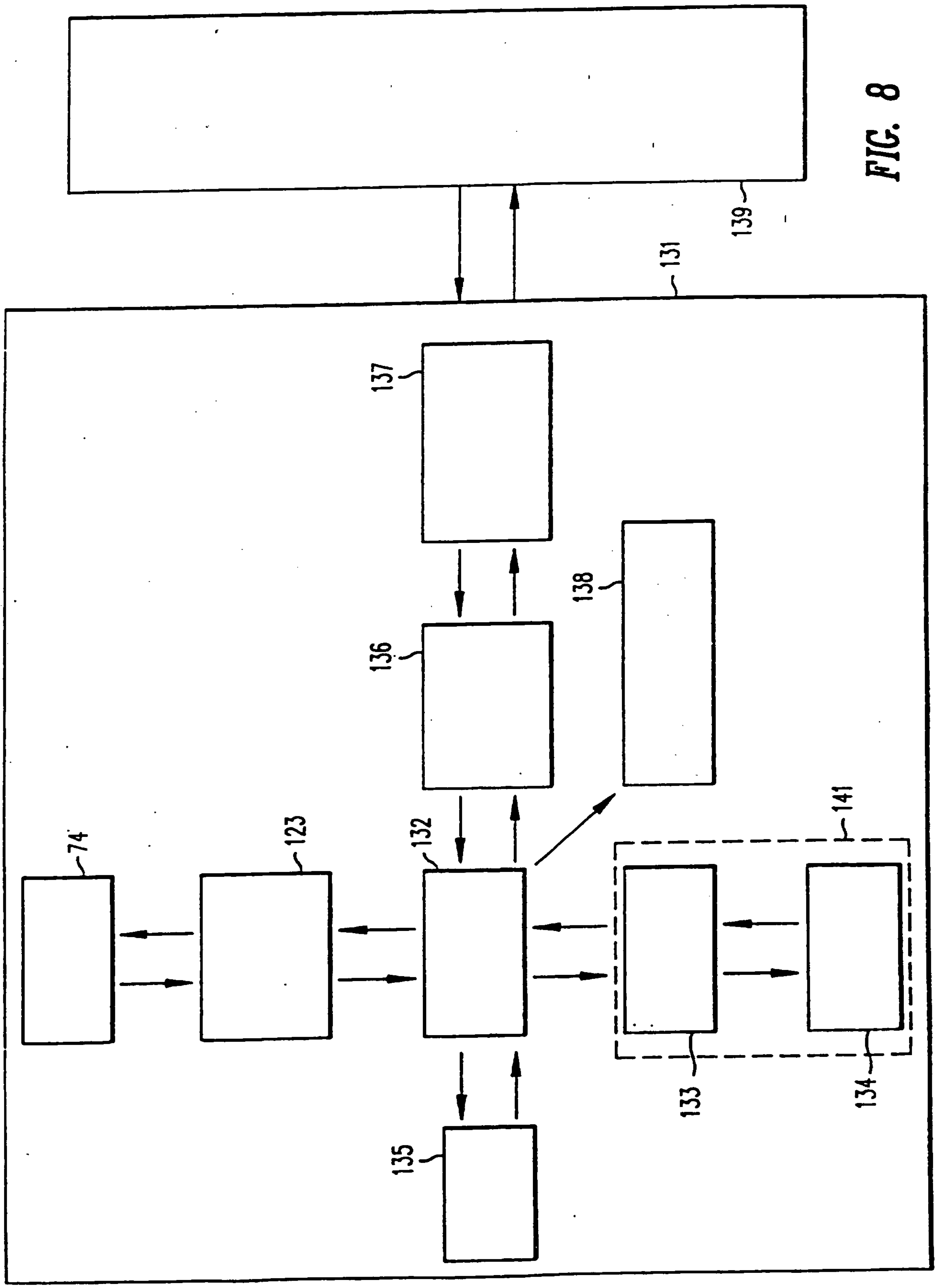

FIG. 8

INTERNATIONAL SEARCH REPORT

Int :onal Application No
PCT/GB 95/02787

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B33/12 G11B25/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 597 186 (HEWLETT PACKARD CO) 18 May 1994 see column 1, line 3 - column 9, line 24; figures	1-5,9,10
A		11-15

X	WO,A,94 29866 (MAXTOR CORP) 22 December 1994 see page 11, line 3 - page 15, line 23; figures	1-5
A		11-15

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 March 1996	12.04.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Declat, M

International Application No
PCT/GB 95/02787

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 35, no. 6, November 1992 NEW YORK, US, pages 30-31, ANONYMOUS 'Assembly Method for Direct Access Storage Device VLSI.' see the whole document	1
X	PATENT ABSTRACTS OF JAPAN vol. 12 no. 154 (P-700) ,12 May 1988 & JP,A,62 270089 (HITACHI LTD) 24 November 1987, cited in the application see abstract	1,2
A	PATENT ABSTRACTS OF JAPAN vol. 17 no. 95 (P-1493) ,25 February 1993 & JP,A,04 291079 (TOKICO LTD) 15 October 1992, cited in the application see abstract	1,2
A	EP,A,0 509 330 (NEC DEUTSCHLAND GMBH) 21 October 1992 see abstract; figures	1
A	EP,A,0 419 022 (IBM) 27 March 1991 cited in the application see column 3, line 14 - column 4, line 19; figures	1,2
A	EP,A,0 475 049 (HITACHI LTD) 18 March 1992 see abstract; figures	1
A	WO,A,94 09486 (INTEGRAL PERIPHERALS INC) 28 April 1994 see abstract; figures	1-4

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. onal Application No
PCT/GB 95/02787

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EP-A-0509330	21-10-92	DE-A-	4112292	22-10-92
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		AU-B-	6130590	28-03-91
		CN-A,B	1051103	01-05-91
		JP-C-	1858820	27-07-94
		JP-A-	3108178	08-05-91
		KR-B-	9407427	18-08-94
		US-A-	5264975	23-11-93
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WO-A-9409486	28-04-94	NONE		